Late Carboniferous to Early Permian palaeogeography of the Italian and central Mediterranean area

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lithofacies,
palaeobiogeography,
oblique rifting,
oceanic crust,
deep sea deposits,
Tethyan realm.

ABSTRACT
An attempt is made at deriving palaeogeographic constraints for late Carboniferous to early Permian restorations from the new stratigraphic data mainly collected in previously poorly known marine deposits of the circum-Mediterranean area. The assumption of an early Permian emplacement of oceanic crust in the eastern Mediterranean Levantine and Ionian Seas is independently supported by the new evidences of deep water facies and faunas from Oman to western Sicily. The bearing on the palaeogeographic reconstruction for the Moscovian and Artinskian time intervals are tentatively suggested by means of two new sketch maps.

MOTS CLÉS
lithofaciès,
paléobiogéographie,
ouverture oblique,
croûte océanique,
dépôts profonds,
Téthys.

RÉSUMÉ
Un essai de reconstitution est fondé sur les contraintes paléogéographiques du Carbonifère supérieur au Permien inférieur, à partir de nouvelles données stratigraphiques acquises sur des dépôts, jusque là assez mal connus, du pourtour Méditerranéen. L'hypothèse d'une croûte océanique du Permien inférieur dans la Méditerranée orientale levantine et ionienne est corroborée indépendamment par de nouvelles preuves des faciès profonds et des faunes d'Oman et de Sicile occidentale. Les reconstructions paléogéographiques pour le Moscovien et l'Artinskien sont effectuées à partir de deux nouvelles cartes.

A critical review of surface and subsurface stratigraphic data published from the Italian area (Fig. 1) in the last two decades or so (references in Cassinis, Cassinis & Ronchi, Di Stefano & Gullo, Pasini & Vai, Vai & Venturini, this volume) has changed quite considerably the usual interpretative palaeogeographic scenario of the central and western Mediterranean areas in the late Carboniferous to early Permian time interval dominated by different stages of Pangaea development (Bosellini & Hsü 1973; Smith & Briden 1977; Rau & Tongiorgi 1981; Irving

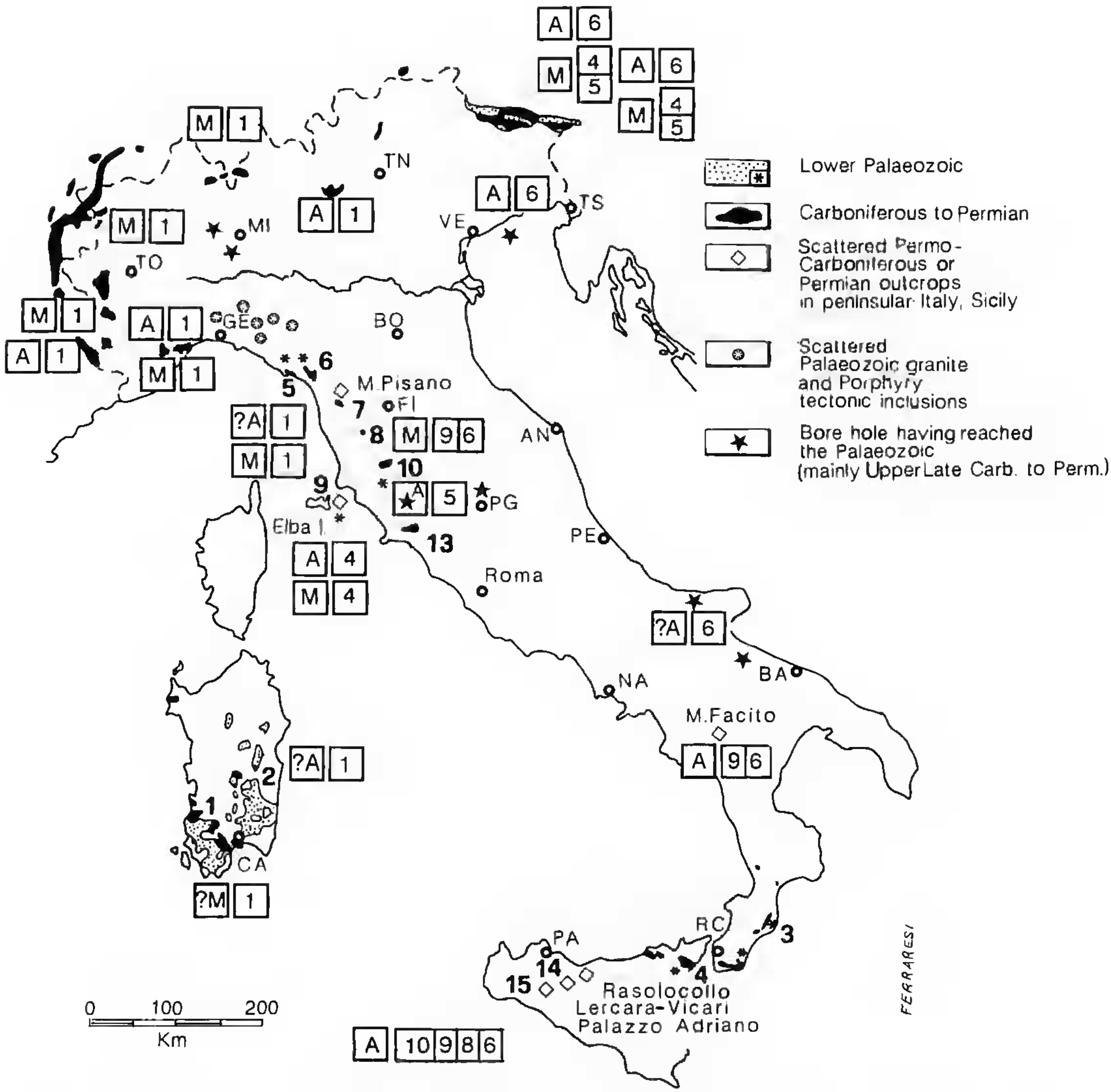

FIG. 1. — Location map of the Palaeozoic rocks in Italy, showing distribution and facies of the Moscovian and Artinskian stages. **M**, Moscovian. **A**, Artinskian. Numbers in boxes relate to legend of figure 3. Numbers in bold refer to stratigraphic sections described by Vai (1978): **1-2**, SW and SE Sardinia; **3-4**, Stilo area and Peloritani Mts., Calabro-Peloritan block; **5**, Punta Bianca, La Spezia; **6**, Apuane Alps; **7**, Pisani Mts.; **8**, Iano; **9**, Elba Island; **10**, Farma area, Monticiano-Roccastrada; **13**, Romani Mts.; **14-15**, Lercara-Roccapalumba and Palazzo Adriano (Sosio), W Sicily. The Verrucano Lombardo, Val Gardena and Bellerophon Formations are not shown.

1982; Sengör *et al.* 1988; Ziegler 1988, 1989).
According to Vai (1994), new data from peninsular Italy and especially from western Sicily suggest an alternative scenario. It is based on two critical points: (1) the deep Ionian to Levantine Sea crust is best interpreted as a fossil, thermally contracted, undeformed oceanic crust emplaced following the early Permian (to possibly mid-Triassic) trans-Mediterranean (to Caribbean) oblique rift; (2) the distribution of the benthic marine Tethyan fauna (fusulinids, brachiopods, etc.) requires a sea-way connecting western Tethys to Texas, Bolivia and Colombia during part of the Permian. Recent reviews of the regional Permo-Triassic data from Sicily (Catalano *et al.* 1995; H. Kozur, comm. at the XIII ICC-P, Krakow, 1995) are consistent with the previous scenario.
This short contribution is aimed at providing a tentative palaeogeographic interpretation of the data collected from the Italian area and described in the five previous contributions (this volume). A synopsis of data is presented in figure 1. The meaning of the data in the frame of the Mediterranean is discussed sepatately following a stratigraphic order.

LATE CARBONIFEROUS: MOSCOVIAN (Fig. 2)

The Moscovian palinspastic picture around the present Mediterranean areas is dominated by an emergent area to the north (main Hercynian Europe) and a marine area to the south. This marine area is separated into an eastern partly oceanic portion and a western shallow epicontinental sea by the north-south trending large peninsula shown as the Africa Promontory merging northward to the Hercynian Europe in the Alps region.

The Italian area proper can be separated palinspastically into four parts:
1. The intra-Hercynian eastern part includes the entire Southern Alps to outer Dinarides segment. From west to east both the Hercynian chain and its post-Hercynian cover show a consistent transition from inner to outer tectono-metamorphic zones and from continental through shallow marine to deeper marine depositional environments. Palaeobiogeographic affinity of benthic animals (fusulinids, corals, brachiopods, trilobites) mainly points out to the Russian Platform, the Urals and middle Asia. Floral elements have western European Eurasian affinity.
2. The extra-Hercynian Panafrican foreland of the African Promontory. It is mainly represented by uplifting basement areas with ongoing erosion and possible thin marine ingtession over its middle westetn part (in the Gargano 1 well area).
3. The intra-Hercynian Tuscan Apennine part. This area, poorly known until recently, is of special interest because it shows an almost continuous marine deposition from early-middle Carboniferous to early Permian in a foredeep-foreland setting (as for the setting of Cantabria and the south Portuguese zone). Again from north to south a transition from inner to outer tectonometamorphic zones appears. Depositional environments, however, range from continental to shallow marine and deeper marine clastics, to shallow marine carbonates and to emergent foreland. Fossil groups such as corals and conodonts show major biogeographic relation with Spain and central American faunas (Ferrari *et al.* 1977), whereas floral elements are typically western European.
4. The intra-Hercynian Sardinia-Calabrides-Kabylides-Betides partis characterized by scattered, thin and poorly developed late Carboniferous to Permian continental deposits with west European floral affinity.

At a more general level, active fronts are found only in the oceanic domain. The continental crust domain is relatively quiet: no first order transcurrent or transform faults appear. The extent of shallow marine deposits outside the Hercynian front and even inside is quite large (and larger than in the Permian). This suggests a low isostatic uplift rate of the orogenic area, consistent with small volumes of deep seated granitoid intrusions. Both land and shallow seas are characterized by a tight network of small-scale pull-apart basins. This time interval is dominated by extension to small-scale transtensional conditions.

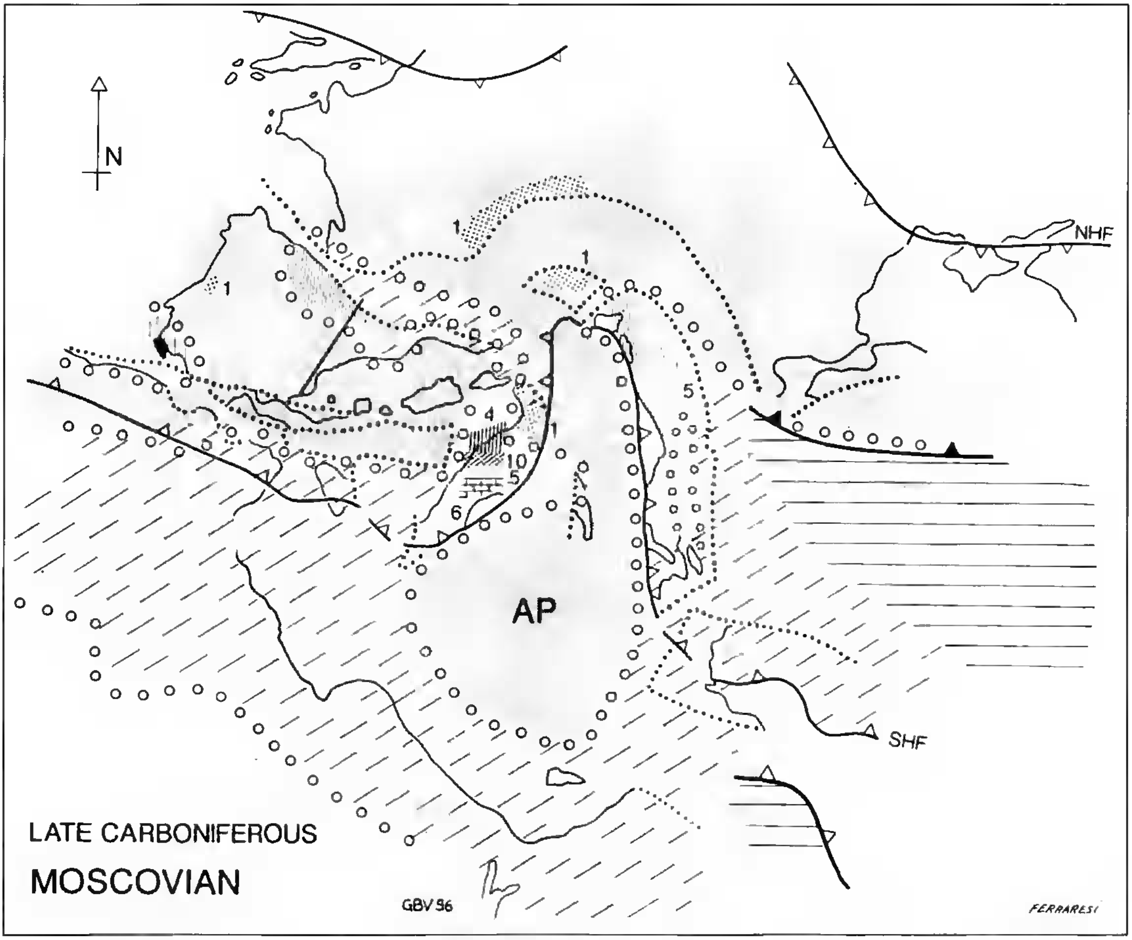

FIG. 2. — Tentative Moscovian palaeogeographic-palaeotectonic map of the circum-Mediterranean area. **AP**, African Promontory during the late Carboniferous. **NHF-SHF**, north and south Hercynian fronts. See figure 3 for legend, and Vai (1994) for further explanations of symbols.

LATE EARLY PERMIAN: ARTINSKIAN (Fig. 3)

Two quite contrasting processes are shown on the map. A prominent regressive trend is documented in northern Africa, from Arabia to large parts of Lybia and Algeria, and in the Cantabrian region (compare figure 3 with figure 2). Relevant trangressive conditions are shown in the rifting Black Sea (Dobrugea) and Iulian-Carnic areas, and even more all through the south Mediterranean region as far as Tunisia.

The former African Promontory becomes kinematically detached from its mother Africa by the westward opening of the Permo-Triassic Tethys, and gives rise to a structurally independent Adria block surrounded by the southern front of Hercynian Europe. The larger southern part of the Adria block becomes submerged by the Artinskian shelf sea. Again, the Italian area can be divided into four parts:

1. The Southern Alps and external Dinarides with depositional environments ranging from continental to shallow marine carbonates to deeper marine clastics passing eastward to the contracting Palaeo-Tethys branch. Both benthic organisms and conodonts suggest Russian to Chinese palaeobiogeographic affinity.

2. The Adria block with mainly erosional continental conditions to the north and shallow marine deposition to the south with important carbonate platforms.
3. The Tuscan, Southern and Sicily Apennine belt (extending westward to the Tunisian Maghrebian chain). It shows transition from continental deposits in northern Tuscany (San Lorenzo Basin, Mt. Pisano) to shallow clastics and carbonates in southern Tuscany (Elba Island, Farma area) to a complete sequence of depositional environments from shallow-water carbonate platform to deep pelagic and turbidite, whose rocks are often reworked as in the tectonically shorthened Mt. Sicani (Sosio valley, and surrounding areas, western Sicily).
4. The Sardinia-Calabrides-Kabylides-Betides belt characterized by erosion or thin continental deposition.

At a more general level, the following facts are relevant.

There is a general major coast line retreat concurrent with the trangressive character of marine deposits in the Mediterranean belt. This is mirrored by the fact that the Permian starts with a transgression followed by regression at a global level and especially in Gondwanaland, whereas an initial regression is followed by transgression in the Hercynian Southern Europe and Northern Africa.
Large volumes of volcanics and epiplutonic granitoids are emplaced concentrating along preferred narrow belts (*e.g.* the Venetian and the Lombardy Lakes-Corsica belts) close to major shear lines.
The already actived large-scale dextral megashear in the Levantine and Ionian Seas is propagating westward, accompanied by additional fragmentation of W Europe and its foreland by means of a conjugate megashear system.
The expanding Permo-Triassic Tethys shifts Cimmeria in such a way as to close the Palaeo-Tethys ocean. Deep marine calcareous to radiola-

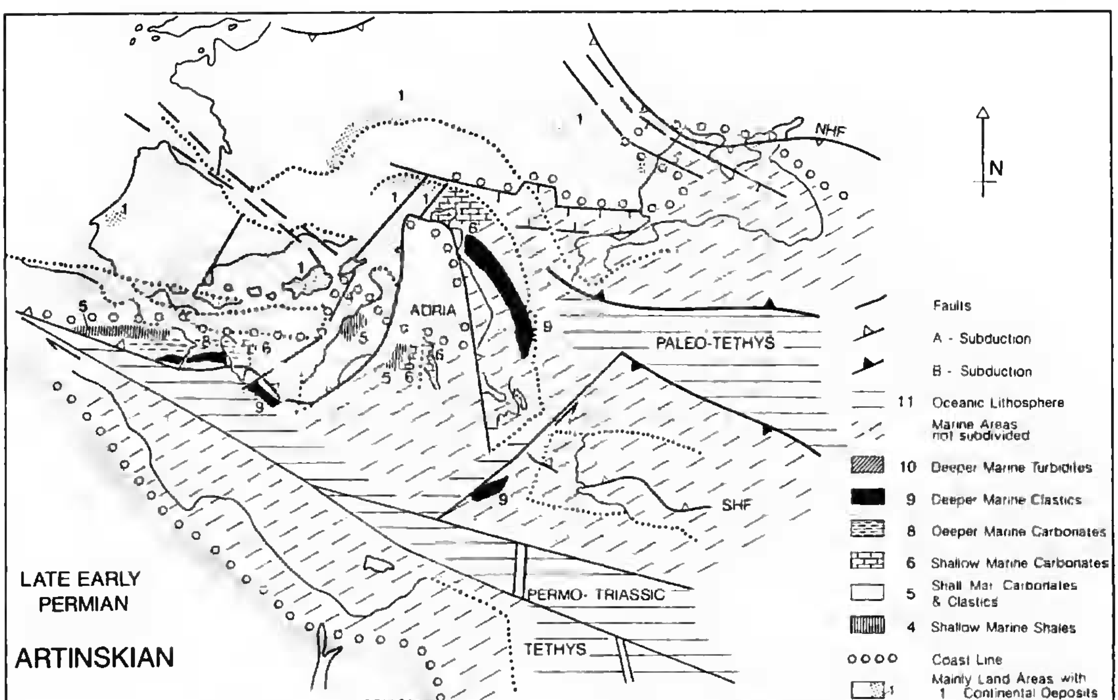

FIG. 3. — Tentative Artinskian palaeogeographic-palaeotectonic map of the circum-Mediterranean area. Notice the intra-Permian crustal separation of Adria from its Precambrian to late Palaeozoic motherland Africa (see figure 2 for symbol explanation).

ritic facies have a climax within the eastern and central Mediterranean area which will be more or less continuing up to the late Triassic especially in the two Permo-Triassic Tethyan edges. In fact, the regionally anomalous marine to deep marine Permo-Triassic or Triassic sequences (or material) of Punta Bianca (N Tuscany), Monte Quoio (S Tuscany) and Lagonegro (Lucania) can be connected only with a south-eastern sea-way. The mid Triassic alkaline volcanics of W Sicily, Punta Bianca, Lagonegro, Budva, Pindos (all associated with deep pelagic rocks) and those similar of the Iblei Mts. in E Sicily (associated with shallow-water carbonate platform) are consistent with this picture. This is further true also for the deep-pelagic calcareous to radiolaritic Triassic facies in Halstatt (Austria), Lagonegro (S Italy) and Sicani Mts. (W Sicily), which are located just at the apex of the closing northern Tethyan arm and of the opening southern Tethyan arm.

DISCUSSION

Some points need to be stressed.

1. The Early Permian marine belt ranging from Tuscany to Sicily may have extended westward to the Tunisian and Algerian Maghrebian chain. However, the internal Apennine units containing these important Permo-Carboniferous marine deposits in the Apennines and Sicily are less exposed in the Maghrebian chain where they may be tectonically buried under the more internal Kabylid nappes or submerged in the western Mediterranean offshore.

2. The famous thick mid to Late Permian marine deposits of Tunisia outcropping in the Djebel Tebaga near Medenine and cored from the well at Bir Soltane (Douvillé *et al.* 1933; Skinner & Wilde 1967; Vachard & Razgallah 1993) are structurally quite distinct from the Permian of Sicily. In fact they represent an epi-Baikalian cover, faulted and tilted before Triassic deposition and gently folded during neo-Alpine deformation. It is located at the south-western edge of the Pelagian Block, close to the limit with the southern Atlas chain and the almost stable Sahara Platform. Moreover, the mixed shaly-sandy and carbonate facies of shelf environment shows a clear shallowing upwards (Bellerophon dolomitic facies and red Triassic continental sandstones), whereas the deep water Permian strata of western Sicily is followed by deep water Triassic limestones and radiolarites. However, the approximately 1700 m of marine mid to late Permian exposed in southern Tunisia clearly suggests an important subsiding basin possibly parallelling the two opposite southern (Sahara Platform) and northern (Sardic-Calabrid-Kabylid-Betic) belts characterized by continental Permian. The E-W trending marine Permian of Tunisia is unconformably sealed westward mainly by onlapping Cretaceous deposits, before being tectonically buried under the Maghrebian thrust belt. The Maghrebian thrust sheets are usually detached from Triassic evaporitic layers. So, there is quite a chance to have a buried E-W trending marine Permian basin filling incorporated within the "basement" all along the Maghrebian chain as far as the northern Moroccan Atlantic coast.

3. According to Kahler (1974) the Fusulinid fauna from Tunisia is immediately younger (Murghabian) than and has no species in common with the one from Sicily, although a short time overlap exists between the two faunas. This is mirrored by a quite different original position of the two areas and may suggest a physical barrier (*e.g.* a deep although narrow sea-way) separating the Tunisian shelf to the south from the Sicilian basin and shelf to the north.

4. There is a prominent marine character of both late Carboniferous and early Permian depositional environments of the Tuscan to Sicilian Apenninic to Maghrebian belt as compared with the remaining three other palinspastic units now assembled into the Italian area and characterized by the usual European continental facies (with exception of the eastern Southern Alps and Dinarides). This is well consistent with and needed to explain Triassic marine deposits practically surrounded by continental deposits (as for the Punta Bianca near La Spezia marine Early to Middle Triassic sequence with pillow-lavas) or deep water facies apparently isolated within shallow-water platforms (as for the Triassic Lagonegro basinal deposits and volcanics) (Vai 1994).

5. The reported South American affinity of the Moscovian Tuscan conodont fauna requires a connection which can be found across NW Africa. In fact, after the peak late Viséan transgression over most of NW Africa, marine sedimentation was reduced to an E-W trending wide belt including the Fourhal, Jérada, Colomb-Béchar, Reggan, Illizi Basins in the Sahara Platform, where it lasted until most of the Moscovian (Conrad *et al.* 1980; Fabre 1983; Legrand-Blain 1983). Marine Moscovian is also known from the SW Moroccan Meseta (W of Fkih ben Salah; Choubert & Faure-Muret 1956). This marine belt can be traced westward to South America in the Amazon Basin and the Northern Andes (Ferrari *et al.* 1977 for ref.). In the remaining part of the Meseta as well as in the Kabylid-Riff and Betic nappes, Permo-Carboniferous and Permo-Triassic continental deposits are only known. In the intermediate Riff and Atlas thrust belt no Permo-Carboniferous information is available because the individual thrusts are detached at the Triassic level. The NW Africa Moscovian sea was probably connected with the south Portuguese zone, where thick foredeep marine deposits as late as Moscovian are known, whereas continental Westfalian and Stephanian rocks were accumulating in the northern Portugal.

6. The reported Spanish affinity of the Moscovian corals from Tuscany suggests the way to connect the almost isolated late Carboniferous Cantabrian Basin with the world ocean system through a Corsica-southern France and eastern Spain corridor. In this respect, the rich Viséan marine fauna of the Montagne Noire (Mamet 1968), Mouthoumet, Pyrénées and Catalonia, followed by mid Carboniferous (Namurian-Westfalian p.p.) turbidites (Ebner 1991), is consistent with the suggested connection. The same applies to the Tournaisian (Krylatov & Mamet 1966) of the N Corsica Capitello limestone and overlying shales cut by rhyolitic dykes and followed by late Westfalian megafloral deposits.

7. As a conclusion one can say that a series of new field data (Catalano *et al.* 1991; Vai 1994; papers in this volume), together with reasonable assumptions based on indirect evidences, would suggest an early to mid Permian sea-way cutting across North Africa and Iberia (*i.e.* separating Gondwanaland from Laurussia) as claimed by Vai (1994). Further support to this hypothesis may derive from the contrasting distribution pattern of provincial floral (Chaloner & Meyen 1973) and continental vertebrate (Romer 1973; Millsteed B., Schneider J. W., pers. comm. 1995) elements passing from Permo-Carboniferous to late Permian-early Triassic. However, effective demonstration of this idea can only derive from either subsurface data beneath the Atlas thust belt or submarine drilling along the Moroccan Atlantic continental margin.

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